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(U) OHIO STATE UNIV COLUMBUS P K GOEL ET AL. FEB 87
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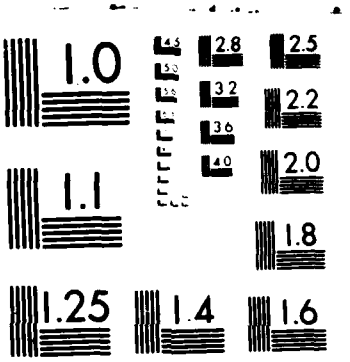

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Prem K. Goel and Mark Berliner

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FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
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Bayesian Computing, Bayesian Software

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The workshop featured eleven talks concerning various issues and applications of computational Bayesian analysis. All presentations were followed by informal discussions.

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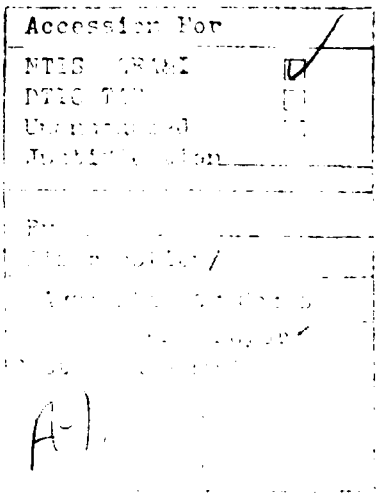
UNCLASSIFIED

20. ABSTRACT CONTINUED

The issues raised focused on (i) which computing environments are desirable for Bayesian statistical analyses, and (ii) what are the potentials for a Bayesian software package.

In the beginning, there was division of opinions about suitable environment for interactive Bayesian analyses and the question of how to start the process. However, an overwhelming majority of participants agreed with the idea that it is too early to push for a new statistical package. Instead we should all push for new software to be compatible with a package like S so that one could use its data handling and graphics capabilities.



Final Report

on

A Bayesian Statistics Year at The Ohio State University

held at

The Ohio State University
Columbus, Ohio

Submitted to

U. S. Army Research Office
Sponsor Grant #DAAL03-86-G-0074

by

Professors Prem K. Goel and Mark Berliner
Department of Statistics
Ohio State University
1958 Neil Avenue
Columbus, OH 43210

As part of the Bayesian Statistics year at The Ohio State University a *Bayesian Computing Workshop* was held May 18 and 19, 1986. This workshop followed the *32nd NBER-NSF Seminar on Bayesian Inference in Econometrics* held on May 16 and 17, 1986. The workshop was sponsored by the U. S. Army Research Office along with the Department of Statistics, the College of Mathematical and Physical Sciences and the Office of Research at The Ohio State University. Some of the participants attended both the workshop and the NBER-NSF Seminar. Travel expenses for some of these participants were shared. Thus the seminar was also co-sponsored by the U. S. Army Research Office and The Ohio State University. The two programs are given in Appendix I.

The list of participants in the seminar and the workshop is included in the Appendix II. All the participants in the workshop were invited by the organizers. The sample correspondence is included in Appendix IV.

The workshop featured eleven talks concerning various issues and applications of computational Bayesian analysis. All presentations were followed by informal, often lively, discussions. In the spirit of a workshop atmosphere, a two hour "working lunch" was devoted to an open forum on Bayesian computing. The issues raised focused on (i) which computing environments are desirable for Bayesian statistical analyses, and (ii) what are the potentials for a Bayesian software package.

In the beginning, there was division of opinions about suitable environment for interactive Bayesian analyses and the question of how to start the process. However, an overwhelming majority of participants agreed with the idea that it is too early to push for a new statistical package. Instead we should all push for new software to be compatible with a package like S (an AT&T trademark) so that one could use its data handling and graphics capabilities. Furthermore, we should start a 'Bayesian Bulletin Board' which will give news about Bayesian programs as they are developed and a 'Bayesian Software Data Base' which could be accessed via networks popular among academia. This would be done either at Carnegie-Mellon University's Statistics VAX or at The Ohio State University's Math-Stat PYRAMID.

All the participants agreed with the fact that there is a pressing need for a software package which will provide an on-line interactive environment to the user. Without such a package, a wide-spread use of Bayesian Methodology will not become a reality. However, one needs fast numerical-integration and Monte-Carlo integration algorithms suitable for 20-30 dimensions. Several statisticians are working on these aspects.

The abstracts of talks are given in appendix.

APPENDICES

I. WORKSHOP & SEMINAR PROGRAMS

II. LIST OF PARTICIPANTS IN THE WORKSHOP AND THE SEMINAR

III. ABSTRACTS OF PRESENTATIONS AT THE WORKSHOP

IV. CORRESPONDENCE

Department of Statistics
The Ohio State University

Bayesian Computing Workshop

May 18th-19th, 1986

Sponsors: The U.S. Army Research Office and The Ohio State University

Organizers: Mark Berliner and Prem Goel

Meeting Place: Room 234, Medical Administration Building
Meiling Hall, 370 W. 9th Avenue
The Ohio State University

Note: Moderator of each session shall act as chairperson and discussion leader. They may start the session with their own prepared comments.

Sunday, May 18th

1:30 - 2:45 **Opening Address**

A.F.M. Smith, University of Nottingham
Numerical Integration and Graphical Reconstruction Strategies for Bayesian Statistics

Moderator: J. Berger, Purdue University

3:00 - 4:15 **Issues in Bayesian Computing**

A. O'Hagan, University of Warwick
Exploring a High Dimensional Posterior Density

H. Rubin, Purdue University
Unusual Considerations for Bayesian Computation

Moderator: J. Kadane, Carnegie-Mellon University

4:15 - 4:30 Coffee Break

4:30 - 6:00 **Bayesian Computing Studies**

J. Monahan, North Carolina State University
Computational Problems in a Fully Bayesian Analysis of ARMA Models

N. Singpurwalla, George Washington University
Interactive Reliability Assessment Incorporating Expert Opinion and Survival Data

Moderator: W. DuMouchel, M.I.T.

7:00 - ____ **Cash Bar and Dinner (at Wine Celler)**

Monday, May 19th

9.00- 9:30 Coffee and Donuts

9:30-11:30 **Bayesian Analysis and Artificial Intelligence**

W. Eddy, Carnegie-Mellon University
Uncertainty in Rule Based Systems

A. Whinston, Purdue University
Bayesian Decision Theory and Expert Systems

M. Yousry, AT&T Research Center
The Intelligent Analysis System

Moderator: E. Wegman, George Mason University

11:30 - 1:30 **Working Lunch**

Open Forum
Bayesian Computing:State of the Art Assessment

1:30-3:30 **Bayesian Computing Techniques and Software**

J. M. Steele, Princeton University
Can YACC Help Create a Bayesian Interpretation?

L. Stewart, Lockheed Research
Monte Carlo Integration in Bayesian Analysis

R. Kass, Carnegie-Mellon University and
L. Tierney, University of Minnesota
Asymptotic Approximations in Interactive Bayesian Analysis

Moderator: M. Schervish, Carnegie-Mellon University

Program of the Thirty-Second NBER-NSF Seminar on Bayesian Inference in Econometrics

Meeting Days: **Friday and Saturday, May 16 - May 17, 1986**

Meeting Place: **The Ohio State University**
Fawcett Center for Tomorrow
2400 Olentangy River Road
Columbus, Ohio 43210

Seminar Leader: **Arnold Zellner**

Program Organizers: **Mark Berliner and Prem Goel**

(Co-Sponsored By: Office of Army Research & The Ohio State University)

Friday, May 16

8:30-9:00 Coffee and Donuts

9-10:30: **Topics in Bayesian Inference**

Seymour Geisser, University of Minnesota, "Measures of Discordance"

Ron C. Mittelhammer*, Washington State University, and Roger K. Conway, U.S. Department of Agriculture, "A Revised Theory of Mixed Estimation--A Subjectivist Interpretation"

Jim Press, University of California at Riverside, "Asymptotics for the Ratio of Multiple t-densities"

10:30-11:00 Coffee

11-12:30: **Utility and Likelihood**

Morris H. DeGroot*, Carnegie-Mellon University and The Ohio State University, and M. J. Bayarri, Carnegie-Mellon University and University of Valencia, Spain, "What is the Likelihood Function"

Herman Rubin, Purdue University, "Non-existence of a Social Welfare Function With Cardinal Utility"

Mark J. Schervish, Carnegie-Mellon University, "Bayesian Decision Theory with Partial Orders"

12:30-2:00 Lunch

2-3:30: **Hierarchical Bayes Analysis**

Yoel Haitovsky*, University of Pennsylvania, and J. V. Zidek, University of British Columbia, Vancouver, "Approximating Hierarchical Normal Priors Using a Vague Component

Rob Kass, Carnegie-Mellon University, "Approximate Inference in Hierarchical Models"

John Deely, Purdue University and University of Canterbury, New Zealand, "Hierarchical Bayesian Models"

3:30-4:00 Coffee

4-5:45: **Uncertainty and Information**

James Berger, Purdue University, "Some Remarks Concerning Reference Noninformative Priors"

Mark Berliner* and Prem Goel, The Ohio State University, "Bayesian Inference with Partial Prior Information"

C. Villegas, Simon Fraser University, "On the Probability of a Model"

E. T. Jaynes, Washington University, "A General-Purpose Maximum Entropy Program"

6:30-Cocktails (Cash Bar) and Dinner at Holiday Inn

Adrian F. M. Smith, University of Nottingham, U.K. (After Dinner Speaker)

Saturday, May 17

8:30-9:00 Coffee and Donuts

9-10:30: **Regression and Econometrics Models**

Robert A. Connelly, University of North Carolina--Greensboro, "Financial Market Influences on Aggregate Money Demand: A Bayesian Analysis"

Anirban Das Gupta, Purdue University, "Restricted Risk Bayes Estimation in Multiple Regression"

Yasuto Yoshizoe, Carnegie-Mellon University, "A Bayesian Analysis of the Binary Regression Model"

10:30-11:00 Coffee

11-12:30: **Control and Estimation**

Joaquin Diaz, University of Houston, "Bayesian Analysis of Time Series with Interventions"

Constantine Gatsonis, University of Massachusetts-Amherst, "Bayesian Inference for Ratios of Coefficients in Linear Models"

Nicholas M. Kiefer, Cornell University, "Control of a Regression Process With Unknown Parameters"

12:30 Business Luncheon

APPENDIX II

Bayesian Computing Workshop : Participants

Prof. Maria J. Bayarri, University of Valencia and Carnegie-Mellon University
Prof. James Berger, Purdue University
Prof. Katherine Chaloner, University of Minnesota
Prof. Morris H. DeGroot, Carnegie-Mellon University & The Ohio State University
Prof. John Deeley, Univ. of Canterbury, New Zealand and Purdue University
Prof. William DuMouchel, Massachussetts Institute of Technology
Prof. William Eddy, Carnegie-Mellon University
Prof. A. O'Hagan, University of Warwick
Prof. Bruce Hill, University of Michigan
Prof. Jay Kadane, Carnegie-Mellon University
Prof. Robert Kass, Carnegie-Mellon University
Prof. Michael Meyer, University of Wisconsin - Madison
Dr. Toby Mitchell, Oak Ridge National Laboratory
Prof. John Monahan, North Carolina State University
Prof. Peter Rossi, University of Chicago
Prof. Herman Rubin, Purdue University
Prof. Steve Samuels, Purdue University
Prof. Mark Schervish, Carnegie-Mellon University
Prof. Nozer Singpurwalla, George Washington University
Prof. A. F. M. Smith, The University of Nottingham, England
Prof. C. Srinivasan,University of Kentucky
Prof. J. Michael Steele, Princeton University
Dr. Leland Stewart, Lockheed Research
Prof. Luke Tierney, University of Minnesota
Prof. Edward J. Wegman, George Mason University
Prof. Andrew Whinston, Purdue University
Dr. Mona Yousry, AT&T Research Center

Ohio State University Participants

Professors J. Aubuchon, M. Berliner, H. Friedman, P. Goel, J. Hsu, J. Klein, D. Malec, B. Nelson, P. Thompson
Miss Kate Ellis, Mr. Panickos Palettas

32nd NBER-NSF Seminar on Bayesian Inference in Econometrics
at
Ohio State University
Non-OSU Participants.

Jim Albert, Bowling Green State University
Richard Andrews, University of Michigan
Maria J. Bayarri , University of Valencia and Carnegie-Mellon University
James Berger, Purdue University
Lyle Broemling,Office of Naval Research
George Casella, Cornell University
Catherine Chaloner,University of Minnesota
Ronald Christensen, Montana State University
Robert A. Connelly, University of North Carolina-Greensboro
Peyton Cook, Math Dept., University of Tulsa
Anirban Das Gupta, Purdue University
Enrique De Alba, ITAM, Mexico City
John Deely, University of Canterbury and Purdue University
Dipak Dey, University of Connecticut
Morris H. DeGroot, Carnegie-Mellon University & The Ohio State University
William DuMouchel, Belmont, MA
George T. Duncan, Carnegie-Mellon University
Joaquin Diaz, University of Houston
Tim Erickson, Boston College
Stephen E. Fienberg, Carnegie-Mellon University
Constantine Gatsonis, University of Massachusetts, Amherst
Seymour Geisser, University of Minnesota
Joel Greenhouse,Carnegie-Mellon University
Yoel Haitovsky, University of Pennsylvania
Richard Highfield, Cornell University
Bruce Hill, University of Michigan
E. T. Jaynes, Washington University
George Judge, University of Illinois, Urbana
Jay Kadane, Carnegie-Mellon University
Rob Kass, Carnegie-Mellon University
Nicholas M. Kiefer, Cornell University
Frank Lad, State University of New York, Albany
John Lehoczky, Carnegie-Mellon University
Richard Leighty, Carnegie-Mellon University
U. Menzefricke, University of Toronto
Ron C. Mittelhammer, Washington State University, Pullman
Carl N. Morris, University of Texas, Austin
Anthony O'Hagan,University of Warwick
Patricia Pepple, Bowling Green University
Daie Poirier, University of Toronto
Jim Press, University of California, Riverside
Peter Rossi, University of Chicago
Herman Rubin, Purdue University
Mark J. Schervish, Carnegie-Mellon University
Teddy Seidenfeld, Carnegie-Mellon University
S.K.Sinha, University of Manitoba
Adrian F.M.Smith,University of Nottingham
J. Michael Steele,Princeton University
Leland Stewart, Lockheed Research, Palo Alto
Luke Tierney, University of Minnesota
Ruey S. Tsay, Carnegie-Mellon University
Hiroki Tsurumi, Rutgers University
C. Villegas, Simon Fraser University
Roger Wright, University of Michigan
Yasuto Yoshizoe, Visiting Carnegie-Mellon University
Arnold Zellner, University of Chicago

APPENDIX III: Abstracts of Presentations

Numerical integration and graphical reconstruction strategies for Bayesian Statistics
A.F.M. Smith.

Interactive quadrature and Monte Carlo techniques for efficient numerical integration in Bayesian Statistics is outlined and illustrated, together with some efficient techniques for density reconstruction and display. This work has been funded by a Science and Engineering Research Council Project Grant and is joint with J. C. Naylor, J. E. H. Shaw, and A. M. Skene.

Exploring a high dimensional posterior density
A. O'Hagan.

We demonstrate that it is possible to explore, and derive plausible posterior inferences from, posterior densities in very many dimensions. We employ simple methods based on derivatives to study the shape of the posterior density. Our approach is advocated whenever the density is complicated, and the resulting summaries are useful when more conventional inferences, based on integrating the posterior, are unavailable. The methods are applied in an example of a 35 dimensional density, in which it is shown that there exists a shoulder which dominates the mode.

Unusual Consideration for Bayesian Computation
H. Rubin

When approaching a problem from a Bayesian viewpoint, it is easy to restrict the prior and loss in such a way that reasonable important aspects of the problem are ignored. It is also easy to put the formulation in such a way that essentially irrelevant aspects take on major importance. We give examples in which these problems arise.

Computational Problems in a Fully Bayesian Analysis of ARMA Models
J. F. Monahan

Statistical analysis of autoregressive-moving average (ARMA) models is an important nonstandard problem. No classical approach is widely accepted; legitimacy for most classical approaches is based solely on asymptotic grounds, while small sample sizes are common. The only obstacles to the Bayesian approach are designing a structure through which prior information can be incorporated and designing a practical computational method. The objective of this work is to overcome these two obstacles. In addition to the standard results, the Bayesian approach gives a different method of determining the order of the ARMA model, that is (p,q).

Interactive Reliability Assessment Incorporating Expert Opinion and Survival Data
N. Singpurwalla

We present a new approach for the analysis of life length data which is assumed to be described by a Weibull distribution. The novel feature of our approach pertains to the incorporation of informed judgement or expert opinion into the analysis, and an implementation of the above on a personal computer in an interactive and user friendly manner. Our approach also makes provision for incorporating the analyst's opinions on the expertise of the experts. Much of our analyses result in graphical displays making our development attractive to a user not comfortable with analytical expressions.

Uncertainty in Rule Based Systems
W. Eddy

The construction of rule based expert systems is reviewed. Bayesian and non-Bayesian techniques for handling uncertainty in the implementation of such systems are compared and contrasted.

Bayesian Decision Theory and Expert Systems
A. Whinston

A development of an expert system for decision making based on Bayesian techniques is presented.

The Intelligent Analysis System
M. Yousry

Locating the root causes of process problems in the manufacturing environment is characterized by a large search space,voluminous amounts of data of varying reliability, and the need to integrate diverse bodies of knowledge. The analysis of such data seems well suited for a hybrid combination of knowledge-based and probabilistic methods. In the system described in this paper, input data is first filtered by an Empirical Bayesian statistical decision process. A rule-based system then integrates these statistics with data from several other sources, including a shop floor control system and on-line product design information, to produce a diagnosis of the cause of the problem.

Can YACC Help Create a Bayesian Interpreter?
J. M. Steele

Yacc (which stands for yet another compiler compiler) is a widely available tool -- it comes with UNIX -- and yacc greatly simplifies the task of writing an interpreter. The aims of this partially tutorial talk are (1) to suggest that the rational development of flexible, interactive Baysian software can "only" be done with the aid of tools like yacc, (2) to suggest that the syntactical discipline enforced by tools like yacc is "good" for the end user, and (3) to illustrate that the aim of "flexibility" in a development system is tremendously fostered by the existance of a grammar specified by production rules.

Monte Carlo Integration in Bayesian Analysis
L. Stewart

A brief description of Bayesian analysis using Monte Carlo integration is given. An example is presented that illustrates the Bayesian estimation of an asymmetric density and includes a display of distribution and density functions generated from the posterior distribution. Other papers are referenced that contain examples that illustrate the power of the approach (a) to handle more accurate formulations of real problems, (b) to analyze difficult models and data for small samples, and (c) to compute predictive distributions and posterior distributions for many functions of the parameters.

Asymptotic Approximations in Interactive Bayesian Analysis
R. Kass and L. Tierney

An on-line demonstration of a program to implement some recently developed asymptotic approximations for integrals arising in Bayesian analysis was held. Analysis of two different data sets was presented in real time via a telephone link to University of Minnesota Computer.

OSU

The Ohio State University

Department of Statistics
141 Cockins Hall
1958 Neil Avenue
Columbus, Ohio 43210-1247
Phone 614-422-2866

APPENDIX IV.

Dear

We are organizing a *Bayesian Computing Workshop* at The Ohio State University from Sunday, May 18th (starting in the afternoon) through Monday, May 19th, 1986. Our intent is to bring together experts in Bayesian Statistics, Computer Science, Decision Analysis, Simulation, and Expert Systems to create an environment for exchange of views and ideas on current and future trends in Bayesian Statistical Computing.

This workshop will feature presentations by invited participants and will include ample time for both formal and informal discussions. Since the lack of a *flexible* Bayesian statistical analysis package hinders the widespread use of the Bayesian methodology, we hope that an end product of this workshop will be some understanding about the contents of a desirable Bayesian package.

This letter is to invite you to participate in the workshop. Please note that the workshop immediately follows the Seminar on Bayesian Inference in Econometrics (SBIE) to be held at OSU on May 16-17, 1986, in order to allow some participants to attend both the activities.

The Office of Army Research and The Ohio State University are providing partial funding for this workshop. Therefore, we will be contribute towards some expenses incurred in attending the workshop. Would you please let one of us know ASAP if it will be possible for you to be here for the workshop?

If you have some ideas about specific topics that need to be discussed during the workshop, please write to us as soon as possible. If you would like to present any concept paper, please send us a title and abstract for it too. We are keeping the format very flexible at this time. However, after we have received all the responses, a definite program schedule will be sent to you.

We very much hope that you will be able to participate in this workshop and the SBIE meeting. With best regards.

Sincerely yours,

Prem K. Goel L. Mark Berliner

To: Colleagues
From: Prem Goel and Mark Berliner
Date: March 3, 1986
Re: Bayesian Computing Workshop

We are organizing a *Bayesian Computing Workshop* at The Ohio State University from Sunday, May 18th (starting in the afternoon) through Monday, May 19th, 1986. Our intent is to bring together experts in Bayesian Statistics, Computer Science, Decision Analysis, Simulation, and Expert Systems to create an environment for exchange of views and ideas on current and future trends in Bayesian Statistical Computing.

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We very much hope that you will be able to participate in this workshop. Would you please let one of us know by March 20th, 1986 if it will be possible for you to attend the workshop?

OSU

The Ohio State University

Department of Statistics
141 Cockins Hall
1958 Neil Avenue
Columbus, Ohio 43210-1247
Phone 614-422-2866

April 17, 1986

To: Colleagues
From: Prem Goel and Mark Berliner
Re: Bayesian Computing Workshp

Enclosed is the program and a list of NonOSU Participants for the Bayesian Computing Workshop to be held at OSU, Sunday and Monday, May 18-19. Participants will be staying at the Holiday Inn on Lane Avenue, next to the university campus.

Please complete the form below and return it to us immediately so that lodging reservations can be made for you. We are looking forward to seeing you in Columbus.

Name _____

Address _____

_____

_____

Lodging

Saturday, May 17th	Yes ( )	No ( )
Sunday, May 18th	Yes ( )	No ( )
Monday, May 19th	Yes ( )	No ( )

Encl.

END

4-87

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